Space Weather Technical Forecast

Issued on Monday, 16 January 2023 at 13:30 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: Further R1/R2 Radio Blackouts expected. Risk of G1/Minor Geomagnetic Storm rising from midweek.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity has been Moderate over the last 24 hours, with one solitary M-class flare observed, a long-duration event M4.8 flare, peaking at 15/1432 UTC from AR3190 in the southeast.

The solar disc remains highly congested in terms of sunspot regions, particularly the eastern solar horizon, with 10 sunspots at present. The main sunspots of note on the disc were those containing potential weak Mt Wilson delta spots (AR3186 and 3190) as well as AR3192, which contains a Beta-gamma magnetic configuration.

No new Earth-directed CMEs have been observed in available imagery.

Solar Wind / Geomagnetic Activity: The solar wind, as measured at L1 by DSCOVR and ACE showed a slight decreasing trend from 470 km/s initially to around 420 km/s by 15/1800 UTC, followed by an increase to a peak of 534km/s at 16/0324 UTC. A subsequent steady decrease to 450-480km/s was then observed by the end of the period. This was attributable to the ongoing waning effects of a CH HSS, superimposed with a CME arrival towards the end of the UTC day on the 15th. The solar wind density appeared on a slowly declining trend until 15/1800 UTC when it began rising, reaching a peak of 28ppcc by 15/2332 UTC. Following this density has gradually returned to near average levels. The IMF was at moderate levels, increasing to reach a peak of 14.1nT at 15/2300 UTC followed by a somewhat erratic drop to mainly weak levels following this. Bz was predominantly weakly negative, but briefly became moderately negative with a peak of -10nT at 15/2254 UTC, before switching to become mostly weakly positive thereafter. The phi angle was generally negative (towards the Sun) until 15/2300 UTC when it became mostly positive (away from the sun). Since around 16/0700 UTC, the phi angle has rotated occasionally through both sectors. Subsequent Geomagnetic activity was Unsettled to Active (Kp3-4) with a G1/Minor Storm (Kp5) interval 15/2100-2359 UTC.

Energetic Particles / Solar Radiation: The high energy proton flux (greater than 10 MeV) as measured at GOES16 has been at background levels throughout.

High energy electron flux (greater than 2 MeV) has varied between Normal Background to Moderate levels on a typical diurnal cycle. The 24-hour integrated electron fluence stayed well below the Active threshold on a very slight increasing trend, reaching 6.78e6 integrated pfu by 16/0000UTC.

Four-Day Space Weather Forecast Summary

Solar Activity: Solar activity is Expected to be Low-Moderate, with a daily slight chance of reaching High levels. Although one of the more active regions departs the front side by midweek UTC, the sheer weight of current and expected eastern solar hemisphere arrivals should serve to compensate.

Solar Wind / Geomagnetic Activity: Solar wind speeds are expected to ease through Day 1 and 2 (16th/17th) due to fading CH and CME effects, but remain at slightly elevated levels. Day

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2023. All Rights Reserved.

3 (18th) may see wind speeds rise to 450-500km/s due to the faint CH65/+ and/or CH66/+. By Day 4, connection to another HSS may take place with winds increasing to around 500-500km/s (elevated). There is then the risk of a CME from the AR3182 twin M-flares of 14th January arriving later day 3 or day 4 (18th or 19th).

Quiet to Unsettled geomagnetic activity is expected through the remainder of Day 1 and into Day 2. Activity should become Unsettled to Active later on Day 3, before increasing to Active to G1/Minor Storm levels into Day 4 for a time, before easing later.

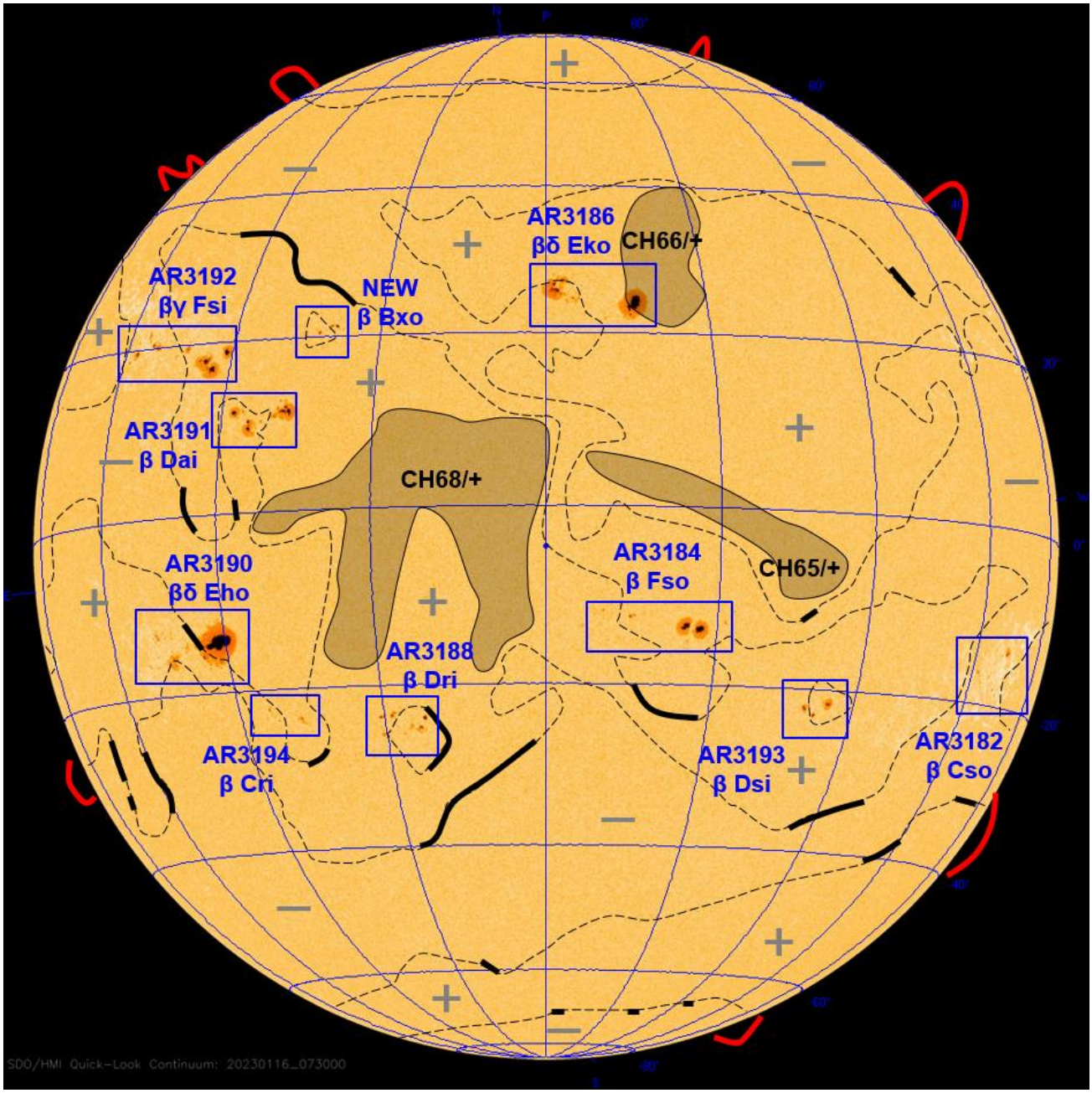
Energetic Particles / Solar Radiation: The high energy (greater than 10 MeV) proton flux observed by GOES16 is likely to remain at predominantly background levels, but with a slight chance of enhancements to S1 or greater through the period due to a number of magnetically complex sunspot regions on the visible disc.

The high energy electron flux (greater than 2 MeV) is expected to continue at largely normal Background to Moderate levels, possibly with a slight upward trend, particularly on Day 2 and 3, but likely insufficient for the corresponding electron fluence to breach Active (1e8 integrated pfu).

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2023. All Rights Reserved.

Figure 1. Solar Analysis Valid 16/0730 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2023. All Rights Reserved.

Geomagnetic Storms:

As the effects from the 11th January CME subsides, solar winds are expected to ease a little, but remain slightly elevated on Day 1 and 2 (16/17th). On Day 3 (18th) the Earth may enter the fast wind regime from one or more fairly weakly-defined coronal holes, located west of centre-disc at present. These are labelled CH65/+ and CH66/+. The former is better located (near the solar equator) to connect with Earth. Ongoing elevated solar activity have served to obscure these regions to some extent, but should it survive, MOSWOC Enlil suggests 450-500km/s is feasible. Furthermore, another obscured HSS (CH68/+) is evident near the solar meridian equatorial region. This appears larger and consistent with the previous rotation (as it is a recurrent feature) could see winds increasing to around 550km/s by the end of the Day 4 (19th).

There is also a risk of a CME from the AR3182 twin M-flares of 14 January arriving to end of 18th or into 19th that may overlap with the onset of the HSS from CH65/+ and/or CH66/+.

Quiet to Unsettled geomagnetic activity is expected through the remainder of Day 1 and into Day 2. Activity should become Unsettled to Active later on Day 3, before increasing to Active to G1/Minor Storm levels into Day 4 for a time, before easing later.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	Yes	5	1	40	60
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
15/0900 UTC	Partial	AR3182	SW Quadrant	400 km/s	Late 18th or early 19th.	Probable hot, reasonable confidence. Onset time lower confidence.

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2023. All Rights Reserved.

Met Office Space Weather Technical Forecast

Radio Blackouts - X-Ray Flares:

Solar activity has been Moderate and is expected to continue at predominantly Low-Moderate levels going forward given the current complex population of sunspot groups on the disc. There is a slight chance of reaching High activity on all days.

Regarding the balance of front-sided sunspot groups, AR3182 should leave the Earth-facing side by midweek UTC, however the vast majority of major contributors to the flare risk should remain, with these very likely to be joined by further active regions over the eastern solar horizon given evidence on far-side soundings. So, while one noteworthy region does eventually depart, on balance the risk of M and X-class flares is held constant.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	Yes	80	80	80	80
Very Active	R3 to R5 X Class	No	15	15	15	15

Solar Radiation Storms - (High Energy Protons):

The high energy (greater than 10MeV) proton flux is currently at background levels.

While no recent S1+ events have been observed at GEO, the sheer number of both front and far-sided complex groups dictates an elevated risk. While the relative contribution to risk will decrease into the new UTC working week for Ex-AR3181 and AR3182, the weight of sunspot regions in the eastern solar hemisphere will increasingly bring itself to bear, resulting in a relatively constant but slight chance of S1+ through the four days.

Radiation Storms	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ S1	No	20	20	20	20
Very Active	≥ S3 *	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2023. All Rights Reserved.

High Energy Electrons Event (≥ 2MeV):

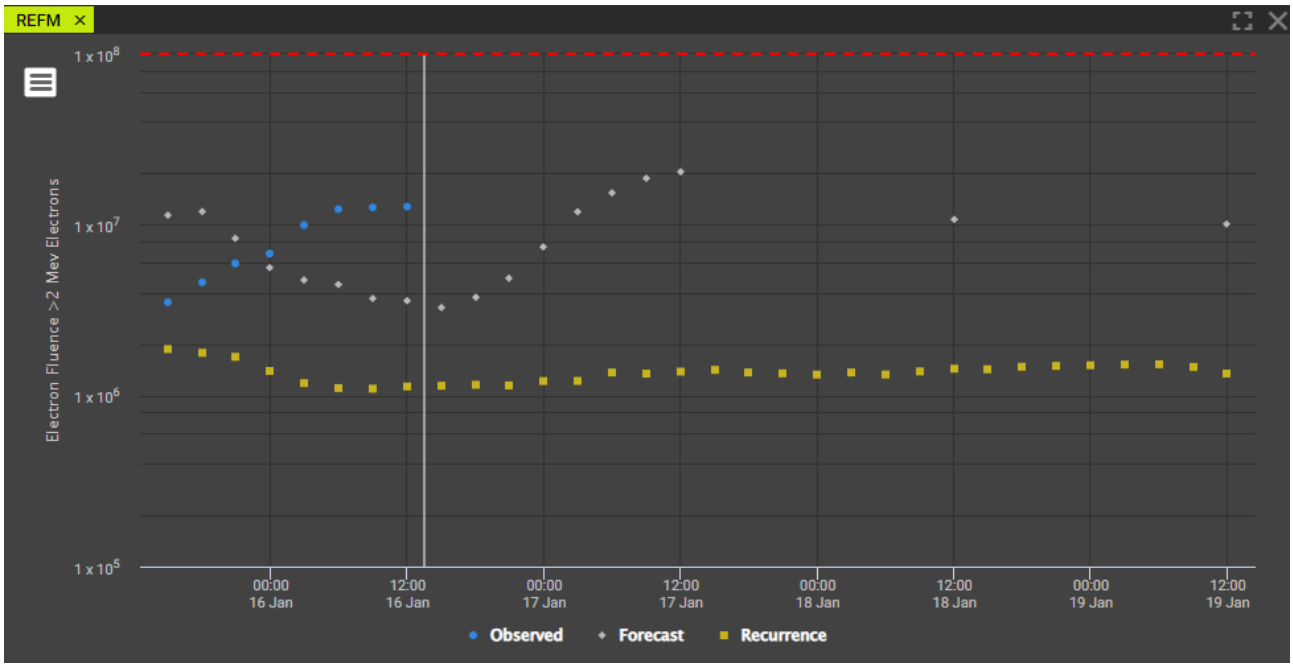
High energy electron flux is oscillating between normal background and Moderate levels as part of the normal diurnal variation. The recent fast wind from CH62/- and effects from the recent CME are continuing to tail off, but have yet to manifest in any increased magnitude oscillation. However it is more likely than not that it will elicit some form of upward reaction in the next couple of days. The degree to which this occurs will most likely prove insufficient for 24-hour Active fluence to be realised, given the modest duration and intensity of the fast wind.

Persistence methods are not considered useful in the period given the apparent lack of similarity of the current disc with last rotation, as well as the presence of CMEs, however REFM is in agreement in the persistence of a sub-Active trend.

All considered, there is a slightly upward trend possible in flux and fluence, but probably peaking by Wednesday 18th, with the CME arrivals later on 18th or on 19th likely to reduce the electron count further.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	10	20	30	10
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

Figure 2: Latest REFM showing observations, persistence and flux forecast.



Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2023. All Rights Reserved.